[0035] System **10** may, if desired, include wireless circuitry and/or other circuitry to support communications with a computer or other external equipment (e.g., a computer that supplies display **20** with image content). During operation, control circuitry **16** may supply image content to display **20**. The content may be remotely received (e.g., from a computer or other content source coupled to system **10**) and/or may be generated by control circuitry **16** (e.g., text, other computer-generated content, etc.). The content that is supplied to display **20** by control circuitry **16** may be viewed by a viewer at eye box **24**.

[0036] In some scenarios, a waveguide is used to form an optical combiner in optical system **20**B. In these scenarios, the waveguide may be subject to total internal reflection and field of view limits, may limit the geometry of optical system **20**B to planar arrangements, and may exhibit undesirable light field capability for rendering virtual objects at any depth from the user's eye (e.g., for solving accommodation-vergence mismatch). In other scenarios, semi-reflective combiners such as ellipsoid mirrors are formed in optical system **20**B. However, combiners of this type are often undesirably bulky and may also exhibit undesirable light field capability for rendering virtual objects at any depth from the user's eye.

[0037] In order to mitigate these issues, optical system **20**B may include a multi-layer holographic combiner. FIG. **2** is a diagram showing how a multi-layer holographic combiner may be used to redirect light from display module **20**A to eye box **24**. As shown in FIG. **2**, optical system **20**B may include multi-layer holographic combiner **40**. Display module **20**A may project input light **56** towards multi-layer holographic combiner **40**. Multi-layer holographic combiner **40** may serve to redirect this light towards eye box **24**, as shown by output light **55**.

[0038] A holographic recording may be stored as an optical interference pattern (e.g., alternating regions of different indices of refraction) within a photosensitive optical material. The photosensitive optical material may include volume holographic media such as photopolymers, gelatin such as dichromated gelatin, silver halides, holographic polymer dispersed liquid crystal, or other suitable volume holographic media. The optical interference pattern may create a holographic grating that, when illuminated with a given light source, diffracts light to create a three-dimensional reconstruction of the holographic recording. The diffractive grating may be a non-switchable diffractive grating that is encoded with a permanent interference pattern, as an example.

[0039] Multi-layer holographic combiner **40** may include multiple layers of material that are recorded with holographic (diffractive) gratings. Each grating may sometimes be referred to herein as a hologram (e.g., a volume hologram). For example, multi-layer holographic combiner **40** may include transmission hologram structures **44** and reflection hologram structures **42**. Transmission hologram structures **44** (sometimes referred to herein as transmission grating structures **44**) may include one or more layers of holographic medium (e.g., thick layers of holographic medium, films, coatings, etc.) that are recorded with a set of transmission holograms. Reflection hologram structures **42** (sometimes referred to herein as reflection grating structures **42**) may include one or more layers of holographic medium that are recorded with a set of reflection holograms.

[0040] Display module **20**A may project light **56** onto transmission hologram structures **44** from a location (angle) external to the volume between reflection hologram structures **42** and transmission hologram structures **44** (e.g., light **56** may be incident on multi-layer holographic combiner **40** from a direction external to the volume between the transmission and reflection hologram structures). This may, for example, eliminate the need for implementing a waveguide between the transmission and reflection hologram structures. Forming multi-layer holographic combiner **40** without a waveguide may eliminate total internal reflection-based limitations on the display. Display module **20**A may include any desired structures for projecting light onto multi-layer holographic combiner **40**. In the example of FIG. **2**, display module **20**A is shown as including a micro display and projector optics (e.g., a lens) for projecting light **56**. This is merely illustrative. In other suitable arrangements, display module **20**A may include a liquid crystal display, an organic light-emitting diode display, a laser-based display, a microelectromechanical system (MEMS)-based display (e.g., a display that implements one or more MEMs scanning mirrors or other MEMS scanning technologies), a digital micromirror device (DMD) display, a liquid crystal on silicon (LCoS) display, a computer-generated holography (CGH) display, or displays of other types.

[0041] Transmission hologram structures **44** may serve to replicate an input image (e.g., an image conveyed by light **56**) at each input ray angle towards reflection hologram structures **42** at multiple different output angles, as shown by light **60** (e.g., transmission hologram structures **44** may serve to split light **56** into multiple beams of light **60** transmitted at different output angles towards reflection hologram structures **42**). Reflection hologram structures **42** may serve to focus the replicated images transmitted by transmission hologram structures **44** onto eye box **24**, as shown by reflected light **55**.

[0042] By replicating the input image using transmission hologram structures **44**, multiple replicas of the input image may be focused onto eye box **24** by reflection hologram structures **42**, as shown in FIG. **2** by pupils **46**, **48**, **50**, **52**, and **54**. In this way, the same image may be replicated at each of pupils **46**, **48**, **50**, **52**, and **54** within eye box **24**, with light **55** forming parallel beams to each of the pupils. This may allow the user to move their eye (e.g., via translation and/or rotation) within eye box **24** without losing the image or generating a shift in perspective to the image (e.g., each of pupils **46**, **48**, **50**, **52**, and **54** may offer the same perspective at eye box **24**).

[0043] When configured in this way, display system **20** may exhibit minimal size, weight, and power consumption (e.g., relative to scenarios where semi-reflective combiners are used) while also exhibiting a relatively large field of view (e.g., relative to scenarios where waveguide combiners that would otherwise be subject to total internal reflection limits are used). Similarly, the absence of a waveguide between transmission hologram structures **44** and reflection hologram structures **42** may allow design freedom in the geometry of multi-layer holographic combiner **40** (e.g., allowing combiner **40** to accommodate other shapes such as curved shapes). In addition, multi-layer holographic combiner **40** may fill eye box **24** with light (e.g., pupils **46**, **48**, **50**, **52**, and **54**) to allow a user to properly view the projected image regardless of the user's facial geometry, pupil diameter, and interpupillary distance, may replicate the image